

Title: "A FLUID PUMP, A FLUID-TRANSFER PLATE AND AN INDUCTIVE SENSOR FOR A FLUID PUMP"

The present invention relates to a fluid pump, a fluid-transfer
5 plate and a sensor for a fluid pump, particularly applicable to linear
compressors, for detecting the position of the respective piston and
preventing the latter from colliding with the fluid-transfer plate upon variations
in the compressor operation conditions, or even variations in the feed
voltage.

10 **Description of the Prior Art**

A linear compressor basically comprises an axially displaceable
piston in a bored-through body, usually a cylinder, the function of the piston
being to compress the gas used in the cooling cycle. The gas-compression
mechanism takes place by virtue of the axial movement of the piston, suction
15 and discharge valves being positioned at the end of the piston stroke, which
adjust the inlet and outlet of the gas in the cylinder. The piston is actuated by
an actuator, which is formed by a support and a magnet, which is actuated by
a coil, this assembly being further actuated by a helical spring, forming a
resonant assembly of the compressor.

20 The resonant assembly actuated by the linear motor has the
function of developing a linear alternating movement, causing the movement
of the piston inside the cylinder to exert a compression action on the gas
admitted by the suction valve up to the point at which it may be discharged to
the high-pressure side through the discharge valve.

25 Variations in the compressor operation conditions, or even
variations in the feed voltage, may cause the resonant assembly to be
displaced more than necessary, thus leading the piston to collide at the end
of its stroke, which causes noises and even damages to the compressor.
Therefore, a means of controlling the piston movement is necessary.

30 Various solutions for controlling the piston movement have
already been proposed, such as that disclosed in document EP 0 398 012,
which describes a sensor located at the end of the stroke of an actuator
piston. Such an actuator is built from a disc manufactured with a conducting

material in order to enable one to determine the distance between the piston and the end of the stroke of the cylinder by means of a magnetic sensor, in order to prevent collision of the piston at the end of the stroke of the cylinder. One of the drawbacks of this solution is that the positioning of the sensor as
5 proposed causes it to be subject to the inner pressure of the cylinder, which results in troubles with the tightness of the equipment, besides complications in the electric connections of the sensor, since the latter is subjected to high-compression areas, and this may cause malfunction thereof as time passes.

Another solution of the prior art is disclosed in document US
10 4,924,675, which describes a linear compressor provided with a magnetic sensor that detects the position of the piston in its stroke by means of the magnetic flow created between the sensor and a magnet existing in the piston. The positioning of the sensor in the external structure of the piston stroke in the cylinder causes this existing wall between the sensor and the
15 piston to be an obstacle for the passage of the magnetic flow that is necessary to detect the piston stroke.

A further solution of the prior art is described in document DE 3246731, which discloses a sensor positioned at the end of the piston stroke, but protuberant with respect to the cylinder structure. With this construction,
20 the piston may collide at the end of its stroke, and the position sensor may be broken or damaged.

Another solution of the prior art is described in document US 6,084,320, which discloses a position sensor positioned at the beginning of the piston stroke and fixed to the piston body. Since in this solution, the
25 sensor moves together with the piston, the possibility of the latter suffering damages due to this movement is great, for which reason this configuration is little reliable, besides bringing complications while assembling the equipment.

Further solutions are described, for example, in documents US
30 4,471,304, US 5,455,509 and EP 0 271 878, which disclose the position of the sensor for detecting the piston stroke at the side of the cylinder and without adequate protection for them. The drawback in these cases is the

need to provide a magnetic layer on the piston for detecting its position, which limits the use of piston types in these configurations.

A problem that exists in the prior art is the fact that a sensor provided on a compressor is subjected to varying pressures, which oscillate
5 between the minimum pressure of the gas or fluid to be compressed and the maximum pressure of the gas or fluid compressed by the compressor. This pressure variation may cause tightness problems to the compressor: (i) since the compressed gas or fluid may leak at the place of positioning the sensor, and (ii) to the monitoring circuit of movement of the compressor piston, since
10 the electric connections of the sensor may be impaired by the high pressures to which the regions where the gas or fluid is compressed by the piston are subjected.

Other approaches to the problem are described, for instance, in document PI 0001404, which discloses a piston-detecting sensor that
15 prevents collision thereof with the cylinder head, provided with an electric probe cooperating with the control circuit. In this case, the detection of the proximity of the piston to its stroke end is effected by electric contact of the piston with the sensor. Although this solution meets the requirements and prevents impact of the piston, this solution using physical contact of the
20 sensor with the piston may generate electric noise, which may interfere with the precision in measurement.

In the face of the drawbacks cited above, the present invention discloses improvements in the area of compressors provided with a piston-position sensor.

25 **Objectives of the Invention**

One of the objectives of the present invention is to provide a fluid pump, a fluid-transfer plate and an inductive sensor for a fluid pump, in such a configuration that it will enable one to indicate the position of the piston inside a linear compressor.

30 Another objective of the present invention is to provide an insulating protector for the piston-position inductive sensor of a linear compressor.

A further objective of the present invention is to provide a piston-position sensor at a location that is subjected to the high pressures of the compressor and that will not suffer mechanical interference between the piston and the sensor, by virtue of the isolation of the inductive sensor from the high-pressure environment.

A further objective of the present invention is to provide a sensor that is inexpensive to manufacture and to implement and, at the same time, has the desired reliability on this type of equipment and that does not have the drawbacks of the solutions of the prior art.

10 **Brief Description of the Invention**

The objectives of the present invention are achieved by means of a fluid pump comprising a piston that is axially displaceable within a cylinder, the cylinder comprising a cylinder closing fluid-transfer plate, the piston being displaced towards the fluid-transfer plate and capturing gas or fluid from a low-pressure environment, and the fluid pump being characterized in that it comprises a sensor assembly that includes an inductive sensor associated with the fluid-transfer plate, the fluid-transfer plate comprises a valve plate provided with a through-bore for association of a protector that cooperates with the bore, the sensor being positioned in contact with the low-pressure environment.

The objectives of the present invention are also achieved by means of a fluid-transfer plate, particularly applicable to a fluid pump and comprising a valve plate provided with a through-bore for association with a protector cooperating with the bore, the protector comprising at least one sensor cavity for association with the inductive sensor.

The objectives of the present invention are also achieved by means of an inductive sensor for a fluid pump, particularly applicable for detecting the piston position, the piston being axially displaceable in a cylinder, the fluid pump comprising a valve plate, the inductive sensor being installed on a protector, the protector being fixed to a through-bore provided in the valve plate.

Brief Description of the Drawings

The present invention will now be described in greater detail with reference to an embodiment represented in the drawings. The figures show:

- Figure 1 is a cross-section view of a fluid pump comprising a sensor protector according to the object of the present invention;
- Figure 2 is a cross-section view in detail of the position-sensor protector according to the present invention;
- Figure 3 is a second embodiment of the protector object of the present invention; and
- Figure 4 is a cross-section view of a third preferred embodiment of the protector object of the present invention.

Detailed Description of the Figures

As can be seen in figures 1 and 2, a linear compressor 1 (or fluid pump 1) comprises a piston 2 that is axially displaceable within a cylinder 3, the cylinder 3 being usually closed at one of its ends with a fluid-transfer plate 40, which in turn comprises a valve plate 4 and an assembly composed of suction valve 4a and discharge valve 4b, these suction and discharge valve 4b being associated to the suction openings 4a' and 4b', respectively, which are provided in the valve plate 4.

The compressor 1 is positioned in a low-pressure environment 11, filled with the gas or fluid that will be compressed by the compressor 1 by virtue of the axial movement of the piston 2 inside the cylinder 3 (or high-pressure environment 11', when the gas or fluid is compressed) by means of the suction valve 4a and discharge valve 4b positioned on the transfer plate 40, which regulate the inlet and outlet of gas or fluid in the cylinder 3. The piston 2 is moved by a motor 66 comprising a magnet 6 that is actuated by a coil 6', helical spring 7 being mounted against the piston 2, so that this spring will always be compressed and form a resonant circuit.

The resonant circuit accounts for the linear movement, causing the piston 2 to make the desired linear movement and consequently compress the gas or fluid from the low-pressure environment 11, which goes in through the suction valve 4a, until it can be discharged to the high-

pressure environment side 11' through the discharge valve 4b and led, for instance, to a cooling circuit (not shown).

The operation amplitude of the piston 2 of the compressor 1 is adjusted with the balance of the power generated by the motor 66 and the power consumed by the mechanism in compressing the gas and other losses. In order to obtain the best performance of the compressor 1, it is necessary to operate at an amplitude at which the piston 2 goes as close as possible to the fluid-transfer plate 40. The operation amplitude of the piston 2 should be known with accuracy. Since, if there are any mistakes, the safety distance for preventing collision of the piston 2 with the fluid-transfer plate 40 will have to be longer. This collision may damage the compressor 1, depending upon its use and application. Moreover, it should be foreseen that, according to the compressor 1 model to which the present invention will be applied, the fluid-transfer plate 40 may be configured in different ways. In some models, the suction valve 4a projects between the valve plate 4 and the piston 2, as shown in figure 2. In this case, the impact will be against the suction valve 4a, and the impact force will be discharged onto the valve plate 4 in other manner than in projects of compressor wherein the impact will occur directly on the cited valve plate 4. In both cases, the impact will be discharged on the fluid-transfer plate 40, which comprises the valve plate 4 and the assembly of suction valve 4a and discharge valve 4b.

A few solutions to this problem have already been discussed in the prior art, but all of them have the already cited drawbacks.

According to a preferred embodiment of the present invention and as can be seen in figures 1 and 2, in accordance with the teachings of the present invention related to the fluid pump, the fluid-transfer plate and the inductive sensor for fluid pumps, one foresees an inductive sensor 8 associated with a protector 9 that, in turn, is associated with the fluid-transfer plate 40, forming a sensor assembly 98. The inductive sensor 8 should be positioned so as to emit a magnetic field towards the piston 2, that the latter, when approaching, will interfere with said magnetic field. In this way, it will be possible to monitor the distance of the piston with respect to the fluid-

transfer plate 40 by means of an electronic circuit (not shown, because it is not an object of the present invention).

In order to make the mounting of the sensor assembly 98 feasible, the fluid-transfer plate 40 should comprise a through-bore 10 for fitting the protector 9, which will isolate the low-pressure environment 11 from the high pressure that occurs inside the cylinder 3 when in phase of compression of the gas or fluid.

The protector 9, which is analogous in shape to the bore 10, should preferably be built in cylindrical shape, since this facilitates the construction of the through-bore 10 and, consequently, the manufacture of the compressor 1, which may be manufactured more rapidly and with lower costs.

In this embodiment, the protector 9 has fitting portions 9c, an open portion 9a and a closed portion 9b, forming a substantially glass-shaped piece with a sensor cavity 8' for accommodating a magnetic sensor 8. Constructively, the protector 9 is associated in such a way, that the fitting portions 9c cooperate with the through-bore 10 by interference, that is to say, the dimensions of the protector 9 should be minimally larger than the through-bore 10, so that it will be firmly seated on the valve plate 4, thus preventing the leakage of gas or fluid out of the cylinder 3, since this gas or fluid - compressed inside the cylinder 3 - may reach high pressures, for example, 30 bar above the pressure in the low-pressure environment 11.

The closed portion 9b will be aligned with the inner face 9b' of the valve plate 4 and, for this reason, will not invade the bore 10 of the cylinder 3. This will prevent the problems of impact of the sensor with the piston 2, thus solving the problems of noise measurement of the prior art. At the same time, this configuration allows the inductive sensor 8 to be positioned exactly at the point necessary to prevent collision of the piston 2, since the interpretation of the value of the magnitude measured on the inductive sensor 8 will be directly proportional to the distance of the piston 2 from the valve plate 4, which facilitates the electronic monitoring of the compressor 1.

The open portion 9a will leave the sensor cavity 8' exposed to the low-pressure environment 11, where the inductive sensor 8 is positioned and fixed preferably against the closed portion 9b of the protector 9 for detecting the distance, and positioned preferably at the end of the piston 2 stroke. As a material for making the protector 9, one should employ a material that will not block the magnetic flow of the sensor 8 too much, for example, stainless steel. Evidently, other compatible metallic materials or even polymeric materials may be employed, as long as they meet the mechanical and electric requirements.

With this embodiment, one achieves the objective of keeping the sensor 8 protected from the high-pressure environment 11, besides permitting passage of the electric connections 88 to an electronic circuit (not shown) for coding and interpreting the signals extracted from the sensor 8. Further, since the open portion 9a is positioned in the low-pressure environment 11, there will be no interference with the electric connections 88, which might be affected by the constant fluctuation of pressure. Another evident advantage resulting from the protector of the present invention is that the access to the electric connections 88 will be facilitated.

Another advantage resulting from the present invention lies in the fact that the inductive sensor 8 cooperates directly with the material that constitutes the piston 2, and it is not necessary for the piston 2 to have a specific magnetic layer for working with the sensor 8. The latter should be constituted by a material that interferes with the magnetic field of the sensor 8, as for example, cast iron, aluminum, copper, etc.

The bore 10 and the protector 9 may be foreseen at any other point of the cylinder 3, or even in any other configuration of the compressor. Likewise, the position of the sensor 8 within the protector 9 may have any constructive configuration.

Further as can be seen in figure 3, according to a preferred embodiment of the present invention, the protector 9 may be fixed between a sealing joint 3' (usually present on compressors) and the proper valve plate 4. In this case, it may be not necessary to make a strict control over dimension tolerances of the protector 9 and of the through-bore 10. In this

embodiment, the valve plate 4 may still comprise recesses 91 for fixing protuberant ends 92, preferably foreseen on the protector 9.

Figure 4 shows another preferred embodiment of the present invention. In this case, the through-bore 10 of the valve plate 4 is closed by a
5 protecting disc 90 instead of the protector 9.

In this embodiment, with the through-bore 10 being closed, a cavity 10' is formed. In this case, the fixation of the protecting disc 90 is effected in recesses 93 configured proportionally to the disc 90, these recesses 93 being provided on the inner face of the cylinder 3. In this case,
10 the sensor 8 will be fixed to the back wall of the protecting disc 90.

Examples of preferred embodiments having been described, one should understand that the scope of the present invention embraces other possible variations, being limited only by the contents of the accompanying claims, which include the possible equivalents.